SCREWWORM ERADICATION

in

FLORIDA

* * *

A Review of Progress Made in Techniques

and

New Developments

During the

STATE - FEDERAL

SCREWWORM ERADICATION PROGRAM

Sebring, Florida

November, 1959

Prepared by
Florida Information Office

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FOREWORD

It is not anticipated that Florida will be obliged to engage in another full-scale program to eradicate screwworms. The joint State-Federal project (1958-1959) gives every indication of complete success.

It has justified the judgment of Florida's governor, its state legislators and members of its delegation in Congress who had the courage to support a drive in 1957 for State and Federal appropriations to finance the program.

The magnitude of the facilities and operations involved in the eradication effort, its use of atomic radiation and its remarkable progress has drawn the attention of scientists in all parts of the world.

The value of research often is difficult to prove until it is given a practical application; however the screwworm program has done just that. It is a triumph of scientific and engineering achievement and a tribute to the fine spirit of co-operation displayed between State and Federal personnel at every level.

The resulting benefits to Florida and the Southeast will amount to many millions of dollars.

Florida is proud of its share in the program and the important advances that have been made during its operation. In eliminating a costly livestock pest from a heavily populated livestock producing area, the way has been opened to great economies in the conduct of any screwworm eradication project that may be considered for other areas in the future.

D.V.M.
State Veterinarian and
Secretary, Florida Livestock Board

INTRODUCTION

New developments that promise material reductions in the cost of conducting a similar project in the future have resulted from experience gained in carrying on the State-Federal program to eradicate screwworms in Florida and the Southeast.

Operated under supervision of the Florida Livestock Board and the Animal Disease Eradication Division of USDA's Agricultural Research Service, the eradication program produced nearly 3 billion sterile screwworm flies. These were dispersed by planes to wipe out the native fly population over an area that ranged from 80,000 to nearly 85,000 square miles, including most of Florida and parts of Georgia and Alabama.

Full-scale operation began on July 10, 1958, with opening of mass-rearing and sterilizing facilities at Sebring, Florida. Prior to that date a "holding" operation was conducted during the first half of 1958 with sterile flies produced in a small pilot plant at Orlando, Florida. These were dispersed in the northern part of the state in an effort to confine screwworm activity to the peninsula until Sebring facilities got into production.

So rapid was the progress of the program that the Sebring facilities ceased operations after 17 months, on November 14, 1959.

On the basis of budget requirements set up for 2 full years, operating cost at Sebring was about 3 1/2 million dollars for the first full fiscal year, or a little less than $55 per square mile for an average dispersal area of 64,000 square miles.

This cost is exclusive of investment in the rearing and sterilizing facilities, estimated at about 1 million dollars, and the cost of maintaining 13 federal inspection stations along the eastern borders of Arkansas and Louisiana to protect the Southeast against re-infestation from the Southwest. Excluded, also, are inspection costs in co-operating southeastern states.

During the final months of rearing and sterilizing and dispersal operations at Sebring, experiments were pressed along several lines indicated by experience in the full-scale project.

Some of the most notable developments, promising material cost reductions and increased efficiency, are reviewed here.

PRODUCTION FACILITIES

A single development by the engineering unit --- the harvesting of larvae by means of a water-conveyor system (see Larvae Rearing) --- makes possible for the future a compact one-story rearing and sterilizing facility, self-contained, and covering a minimum area for the large-scale operations to be housed.

Such a structure would be radically different from the massive two-story laboratory at Sebring and its several additional smaller buildings.

The Sebring location was selected because it offered four important advantages:

(1) A central location in the heart of the peninsula.

(2) A building that was large enough to be adapted to mass-rearing activities.

(3) An adjoining airstrip convenient for dispersal planes.

(4) A sewage disposal plant with capacity adequate to handle a large weekly volume of waste.

Nevertheless, after extensive remodeling, the Sebring mass-rearing laboratory was a compromise. It was not perfect for the purpose and resulted in many problems involving security, temperature and humidity controls, and maintenance. The fact that it operated as well is a tribute to the skill and efficiency of the engineering and rearing staffs in solving each problem as it developed.

Tentative designs for ideal facilities of various capacities have been drawn up by the engineering unit. They incorporate all of the features which, in the light of experience at Sebring, are considered desirable for a future project and offer great possibilities for:

(1) Holding construction and maintenance costs to a minimum.

(2) Reductions in personnel and operating costs.

(3) Increased security against escape of fertile flies.

(4) Closer controls over temperature and humidity.

Because of the possible use of non-protein fibrous materials as additives in the rearing medium, the new designs make provision for drying the large weekly tonnage of spent medium resulting from mass rearing. This could eliminate the need for a large and costly sewage disposal plant and offers the possibility of partially offsetting production costs through income realized by sale of treated waste for fertilizer purposes.

BREEDING AND EGG PRODUCTION

In the Adult Colony, where eggs are produced to start mass-rearing of screwworm flies, a remarkable reduction was accomplished at Sebring in the cost of the attractant used to induce egg laying.

Although the total money saving for a full year's operation with the new method would be modest in comparison with some developments in other departments, the reduction in attractant cost amounted to 91 per cent.

Only after a long series of comparisons had been made to test its reliability was the new attractant put into full use during the final months of Sebring's production.

The original attractant at Sebring, in use for a long time prior to the beginning of operations there, was beef heart extract. The new attractant uses blood albumin.

Following is a comparison of attractant costs for "egging" 6 cages a day at Sebring, exclusive of labor involved, a considerable item in obtaining beef heart extract.

	Beef Heart	Blood Albumin
Cost, per day	$3.16	$0.18
Total cost (365 days)	$1,153.40	$63.70
Average grams of eggs per cage (246 comparisons)	181.3	174.4

MEETINGS AND THE PRODUCTIVE

LARVAL REARING

In larvae rearing, from the point where one-day-old larvae begin feeding on the rearing vats to the time when pupation begins, there have been several important cost-cutting and increased-efficiency developments.

Outstanding is a sharp reduction in the cost of food used in the rearing process. When it is noted that the Sebring laboratory's expense for meat during seventeen (17) months of operation totaled more than nine hundred thousand ($900,000) dollars, the importance of this single item is readily apparent.

In the Orlando pilot plant operations prior to opening of the Sebring laboratory, horse meat was used almost exclusively in the rearing medium. Continuous experiments conducted by the Methods Development unit, first at Orlando and later at Sebring, resulted in substitution of whale meat for horse meat during the last 3 1/2 days of the feeding cycle. At Sebring the ratio of whale meat to horse meat used was about 4 to 1.

Next, it was discovered that a careful leveling of the medium resulted in a considerable saving and increased feeding efficiency. And finally, experiments demonstrated that a finer grind and mixing with an additive, such as cottonseed hulls, permitted exclusive use of whale meat for the entire 5 1/2-day feeding cycle.

Even though whale meat is cheaper than horse meat, supplies of both cannot always be assured in the huge volume required for mass-production of screwworms.

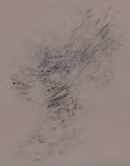
Latest experiments, conducted just prior to the closing of the Sebring facilities indicate that further important reduc-

tions in food costs are possible by substituting for meat, in whole or in part, cheap fish which are available in almost unlimited supply.

The following table gives an indication of the cost reductions achieved in the media experiments.

REPORT ON EFFICIENCY OF PRODUCTION

Release Period Covered	Pounds Of Meat Used	Cost Of Meat Used	No. Of Pupae Released	No. of Viable Flies Released	Ave No Pupae per Lb	Ave. No. of Viable Flies per Pound	Ave. Cost per Million Pupae	Ave. Cost per Million Viable Flies
52 Week Period 8/31/58-8/29/59	5,080,960	$ 883,339	2,905,684,934	2,088,700,263	572	411	$ 304	$ 423
8/30/59-9/5/59	48,510	7,297	34,970,150	22,479,145	721	463	209	325
9/6-9/12	42,750	5,891	31,231,795	21,768,040	731	509	189	271
9/13-9/19	47,260	6,113	36,769,060	31,790,750	778	673	166	192



An additional possibility of further reducing the cost of food per million viable flies for dispersal is indicated by experiments in "Methods Development" to find a way of separating screwworm eggs by sex.

Theoretically, the eradication program evolves from the fact that the native female fly mates but once in her lifetime and, when mated with a sterile male, will produce sterile eggs which do not hatch. Thus, race suicide results.

In the Sebring operations, flies were reared, sterilized and dispersed as they hatched, the sex ratio being approximately equal. Therefore, of about 3 billion flies dispersed, 1 1/2 billion could be said to be superflous for eradication purposes.

Shortly before the Sebring laboratory was closed, it was learned that sexing of eggs may be practical because it was discovered there is a slight difference in the specific gravity of the male and female eggs. Continued experiments may develop a practical method, using a flotation or centrifuge process, of harvesting almost exclusively male eggs for mass-rearing.

Female eggs then would be used in only small volume sufficient to provide adult females for the breeding colony.

Thus, the number of effective flies produced from a pound of food could be nearly doubled and the increased efficiency would be reflected in practically every stage of operation.

To improve rearing efficiency, the engineering unit devised a new type of oil-filled base for vats so heat from electric elements will be spread evenly over the surface containing rearing medium.

Electric power loss will be reduced by use of plug-in contacts at fixed stations on the rearing floor to eliminate long electrified bars on the overhead monorails, and trolley contacts on vat-carrying racks.

A water-conveyor system for harvesting larvae is planned to replace the huge funnels used in the two-story Sebring laboratory. When larvae migrate from the vats they will fall into floor trenches where flowing water will carry them to a collecting-drying unit.

This method tends to deliver cleaner larvae as the water will remove particles of food medium carried from the vats. The cleaning process may be further improved by a detergent bath to remove any oily film which tends to lower pupation efficiency.

Experiments with the water-conveyor method indicated the water bath induces earlier pupation.

PUPAL HANDLING

Elimination of sand for pupation is in prospect. At Sebring a large tonnage of special sand was constantly in use. It required considerable handling and bulky equipment to clean, sterilize, dry and transport it for each re-use.

Preliminary tests indicate satisfactory pupation without sand is obtained by placing larvae in fine-mesh screen bottom trays. Delivery of clean larvae by a water-conveyor method may be an aid to pupation without sand which, however, had some effect in cleaning the worms as they crawled over and into it.

In the Sebring laboratory, pupation occurred in extensive open areas on the first floor. However, it was found a higher and more stable rate of fly emergence was obtained when pupation took place under controlled temperature and humidity such as prevailed in the pupae holding, or aging, room.

Consequently, new plans anticipate pupation in controlled temperature-humidity areas from which larvae and pupae will be removed at regular intervals for separation.

A radical change is planned in a new plant for the unit that will accomplish larvae-pupae separation. In exhaustive test, a model designed by the engineering staff produced eminently satisfactory results.

This novel device utilizes the larvae's inclination to escape from direct light and seek a shadowed, or darkened, area.

After the first pupation cycle, trays contain pupae and

strip of a slowly moving corrugated rubber belt. Over this center strip a channel of light is beamed from above for the entire length of the belt, leaving dark areas on both sides.

Pupae remain on the belt and are carried along to fall into a collecting hopper at one end. But the larvae, seeking to escape from the light, crawl to the dark areas at either side and fall off the belt into lateral collecting hoppers. There they are gathered, put back in trays and make successive trips through the controlled temperature-humidity areas until pupation is completed. They are then ready for final collection and placing in the pupal holding, or aging, room.

IR RADIATION

Two important advances in radiation procedure will be available for future use.

The first is aeration of pupae during the irradiation cycle which begins upon loading into canisters and ends when they are delivered to the packaging room. During that cycle the canisters are lowered into casks containing Cobalt-60 which emits powerful gamma rays that cause sexual sterility of flies which later emerge.

Aeration preserves the oxygen level required by aged pupae and tends to reduce materially the time of exposure and dosage required to accomplish sterility.

During the Sebring operation tubular canisters were used, with only the top open to receive the average load of about 2800 cc of pupae. After loading, a paperboard cover closed the open end. Besides the actual time pupae remained in the Cobalt cask, they also remained in the canister for varying periods depending on procedure followed in the canister loading room, and later in the packaging room.

Tests made during the closing weeks of the Sebring operation revealed that better results are obtained if the pupae in the canister can remain exposed to a normal supply of air.

Satisfactory aeration can be obtained by using a ventilated canister with an open-top, screen-mesh body and bottom, inside of a reinforced framework to give rigidity.

Comparison of standard Sebring irradiation procedure with preliminary results from the aerated method shows:

	Sebring	Aerated Method
Average pupae age(days)	5	5 to 7
Average Dosage (roentgens)	11,000 to 12,000	6,900
Average time required for irradiation	14 minutes	8 1/2 minutes

Thus, aeration will permit each radiation unit to sterilize pupae in a shorter time, increasing the potential of output, and speeding irradiation operations. It also will standardize the sterilization of pupae irradiated.

The second important new development in this department, a step to strengthen fly security, is "straight line" delivery of pupae from "Canister Loading", through "Irradiation" to "Packaging".

In the Sebring operation, irradiated canisters of pupae were returned to the unit operator after leaving the Cobalt cask. He then passed them on to be transported by conveyer to the packaging room.

In "straight line" delivery the canisters will not be returned to the operator but will be deposited, instead, directly on a conveyor to the packaging room.

Thus, one important element of possible human error in handling will be removed by making it impossible to deliver a canister of non-irradiated fertile pupae for dispersal.

Also, radiation facilities are planned to be included in the overall fly security which, at Sebring, covered only the rearing

laboratory. Access to the radiation area will be through the single guarded entrance for all workers, except those in "Packaging", where a strict security routine must be observed by all who enter the building.

Additional radiation safety regulations will apply, as they did at Sebring, to anyone entering the radiation area.

DISPERSAL

A reduction of approximately 38 per cent in the flight costs of aerial fly dispersals is a possibility in a new plan being tested by the engineering staff during the closing weeks of Sebring operations.

Twenty light single-engine planes, each carrying a pilot and an insect disperser, were used to distribute the sterile flies produced at Sebring over the eradication area. Besides the central dispersal center located at Sebring, additional distribution centers were located at Tallahassee, Gainesville, Orlando, and North Hollywood.

Shortly before Sebring facilities were closed, a medium twin-engine plane was obtained on loan from the Navy to test the efficiency of revised dispersal equipment. This equipment includes a new-style, larger dispersal carton with about six times the capacity of those used at Sebring, and a larger, new-style automatic release device to eject opened boxes from twin-engine planes at higher altitudes.

A considerable amount of engineering development work went into the design and construction of the larger cartons and a release device adequate to handle it. Additional work will be required to perfect automatic machinery to form, load and close the new cartons.

During the Sebring operations more than 8 million dispersal cartons, 4 1/2" x 5 1/2" x 2", were used. Each was pierced with 405 small holes for ventilation and contained a 20-cell insert to provide adequate space for flies to rest. Average load per box was about 440 flies.

One type of larger carton is about 10" x 6" x 3 1/2", double-decked inside with four 20-cell inserts. Black porous paper lines the interior, covering 124 half-inch holes and providing adequate ventilation but preventing escape of flies and subduing any strong light. Its capacity is about 2,500 flies.

To eliminate the possible hazards of a falling object the size of the new carton, the new release device will cut it in half and break it open so flies will be freed after both halves leave the plane.

To facilitate handling, loaded cartons may be assembled in magazines for the release device.

Following is a comparison of flight data:

	Sebring	New Plan
Type of plane	Light, single engine	medium, twin engine
Plane capacity (flies)	400,000 plus	3 1/2 million
Average release altitude	1,300 feet	5,000 feet
Average width of dispersal swath	2 miles	8 miles
Plane personnel	1 pilot and 1 disperser	Same
Average estimated weekly flight cost per square mile	13 cents	8 cents

During the testing operations more than 3 million
dispersed neutrons, 6 1/2" x 3 1/2" x 2", were used. Each
was planted with 200 small holes for ventilation and contained
a 30-cell battery to provide adequate space for films to pass
through land are how are about 400 films.

The type of large neutron is about 20" x 6" x 3 1/2",
conformation inside with four 30-cell batteries. Flash proves
proof films the locality, covering 120 half-hour holes and pro-
viding adequate ventilation but preventing escape of films and
receiving any normal light. The capacity is about 1,200 films.

To minimize the possible hazards of a testing engine
the area of the new center, the new science device will use it
is hard and trust it open so films will be kept atom both before
there the plane.

In facilities building, loaded cameras may be operating
by engineers for the science center.

Following is a comparison of flight data:

Type of plane	High-altitude engine	Boeing Jet
Plane number, Signal	1,200 Fms	3 Air Force
Average distance flights		Space Base
Average speed at Observed		
Plane	2 pilots	3 pilots
Plane personnel	1 pilot and	Crew
	1 Observer	
Average estimated speeds		
Flights over 200 square mile	12 hours	2 hours

FIELD OPERATIONS AND SURVEYS

A promising start was made by "Methods Development", during the final stages of the Sebring operations, on experiments to develop one or more strains of mutated, or "marked" screwworm flies.

Such a fly, if it could retain its marker through generation after generation of mass production, and lose none of the qualities to make it effective for eradication purposes, would greatly facilitate and improve the accumulation of important survey data obtained in the field.

If sterile released flies bear a distinguishing mark, they can readily be identified when found in traps and be more easily separated, when trap samples are examined, from any which are not marked.

An early procedure at Sebring to mark all released flies with powdered dyes, applied to pupae during box assembly, proved to be impractical. The dye-marked flies were satisfactory for identification, but continuous large-scale use of dyes developed difficulties in handling and adversely affected automatic equipment used to load cartons. Nevertheless, dyes were used from time to time in special field surveys.

Geneticists had produced insect mutations by irradiation prior to the time Dr. E.F. Knipling proposed, in 1935, his theory for eradication of insects by dispersal of sterile males. So, at Sebring,

a start was made to give the earlier discoveries a practical application in a program having great economic significance.

When production pressure on the six Cobalt-60 units at Sebring eased up enough to make one available for test purposes, experiments were begun to obtain, by irradiation, one or more mutations offering possibilities for rearing strains of marked flies.

Preliminary results of these experiments were so promising that the work was transferred to the U.S. Department of Agriculture's entomology research laboratory at Kerrville, Texas, when Sebring operations started to close down late in October, 1959. The transfer permitted uninterrupted progress to be made with the mutations giving most promise.

Also important in field survey work is the development at Sebring of a collapsible plastic screen-mesh fly tray suitable for use on the ground or to be suspended in the air. Thoroughly tested for several months, it has given excellent results.

When collapsed, this new type of trap occupies very little space compared with the standard rigid wood-frame and metal screen-mesh status trap of which several hundred were used in Florida.

The collapsible trap is ideal for use in areas to which access is difficult, and when transportation facilities limit the amount of equipment space available.

QUALITY CONTROL

In any large-scale continuous production operation, such as the mass-rearing of sterile screwworm flies, it is of vital importance to maintain the quality of the product at the highest level possible at all times.

To keep a close check on the quality of flies being produced, a department of "Quality Control", working under "Methods Development", was established at Sebring. The procedures it employed were evolved as the eradication work proceeded, and contributed materially to the control of overall production techniques.

Regardless of how much costs are reduced, it is obvious that the reductions are useless if they tend to impair the quality of the product to the point where it fails to perform its intended function. In the case of mass-reared sterile screwworm flies, they should be vigorous, vital, aggressive, sexually acceptable and as long-lived as possible.

However, because of the nature of the fly production technique, which is geared to the 21-day life cycle of the insect, it is not always possible to detect deficiencies promptly enough to correct them before they have affected the quality of one or more weeks' output.

"Quality Control" functioned at Sebring in a "watch dog" capacity to provide the earliest possible daily information on efficiency of the various phases in larvae rearing, sterilization and dispersal.

Through "Quality Control" it was possible to detect and correct, from time to time, any inadequacy in techniques, or materials, the continued use of which tended to reduce the effectiveness of the sterile flies that were being dispersed week after week.

Included among the daily checks made by "Quality Control" were:

(1) Two different tests to determine sterilization efficiency.

(2) A check before irradiation to estimate the probable percentage of emergence after the radiation dosage had been administered.

(3) Two different tests on total emergence, emergence after time of release, and survival of adults at time of release.

In addition, "Quality Control" made periodic mortality tests to determine the vigor of the mass-reared flies.

In a future program, this department might be assigned also, the task of checking supplies used in fly production to make sure they meet specification requirements. This would tend to eliminate undesirable materials which, if used, could result in costly production losses.

SCREWWORM ERADICATION PROGRAM

Administrative and Technical Personnel

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State Program Director

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(12-29-57 to 7-1-59)
Dr. F. E. Henderson
(Effective 7-1-59)

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Biological Aide USDA

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(continued)

SCREWWORM ERADICATION PROGRAM

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Entomologist, USDA
Kerrville, Texas

Dr. T. W. Cole
USDA, Veterinarian in Charge
Jacksonville, Fla.

W. E. Bruce
Entomologist, USDA
Washington, D.C.

M. E. Jefferson
USDA Radiological Officer,
Beltsville, Md.

V. E. Weyl
ARS Information,
Washington, D.C.

(continued)

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ACC Instructor
Washington, D.C.

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SCREWWORM ERADICATION PROGRAM
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SEBRING, FLORIDA

C. L. CAMPBELL, D.V.M., SECRETARY
STATE VETERINARIAN

M. E. MEADOWS, JR., D.V.M.
STATE DIRECTOR

January 11, 1960

Dr. R. C. Bushland:
United States Department of Agriculture
Entomology Research Station
P. O. Box 232
Kerrville, Texas

Dear Bush:

The photo arrived safely and looks satisfactory for reproduction. Thanks for sending it promptly.

I am enclosing a thermo-fax of the draft for text of the "Progress Review" which I started working on in October-November, 1959. It is the result of observations in the final months of rearing operations. It looked to me like a good idea to pull all the new developments together in a single review or report. This comes to you with Dr. Meadows' approval.

My original plan was to prepare it for Florida Livestock Board, but Washington asked for a copy which went up in late November, and they have just recently indicated they would like to make revisions. What the eventual result will be I can't say at the moment, but the tentative plan is:

After the title page, about seven pages with photos of individuals (the governor, board members and key screwworm personnel including Dr. Sharman, Mr. Bruce, etc.).

At the end of each division of the text photos illustrating the Sebring equipment, and a drawing or model or photo showing the new development. This will give visual evidence of the contrast. Some things do not lend themselves to illustration, such as the improved attractant for egging medium, and sexing of screwworm eggs.

The text throughout will be annotated with references to letters, reports, drawings etc. concerning the new developments and techniques. These have been furnished by the heads of the various departments who also read and approved the text where mention is made concerning matters under their immediate supervision.

The foreword is written for Dr. Campbell's signature. Any or all of the above may be subject to change before the review is assembled in its final form.

I would appreciate any comments and criticisms you would like to make. May I hear from you?

Cordially,

A. U. Spear
Information Officer

Enc.

CC: T. W. Cole
C. L. Campbell

AUS:tb

The foreword is written for Dr. Campbell's signature. Any or all of the above may be subject to change before the review is assembled in its final form.

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Cordially,

A. D. Beard
Information Officer

Enc.

CC: T. W. Cole
C. I. Campbell

ADB:tb